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NASA Technology Transfer Network Communications and Information System

CONCEPT DOCUMENT

Applied Expertise, Inc.

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INTERIM DRAFT REPORT

RICIS Preface

This research was conducted under auspices of the Research Institute for Computing and Information Systems by Applied Expertise, Inc. Mr. James Wilson served as principal investigator for Applied Expertise. Dr. E. T. Dickerson served as RICIS research coordinator.

Funding was provided by the Information Technology Division, Information Systems Directorate, NASA/JSC through Cooperative Agreement NCC 9-16 between the NASA Johnson Space Center and the University of Houston-Clear Lake. The NASA research coordinator for this activity was Ernest M. Fridge III, Deputy Chief of the Software Technology Branch, Information Technology Division, Information Systems Directorate, NASA/JSC.

NASA Technology Transfer Network Communications and Information System

CONCEPT DOCUMENT

Baseline 1.0

October 15, 1992

DRAFT

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System design should be made to fit the diversity of people using it rather than standardize the people to assume conformity.

- P. Strassmann

NASA Technology Transfer Network
Communications and Information System

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DRAFT

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In today's environment of heightened global economic competition, U.S. industry must be positioned to respond to new commercial and technical challenges. It must combat declining productivity and losses in important industrial markets by, among other measures, devoting adequate resources to research and development and by applying new technologies and laboratory innovations to the manufacturing sector. In recent years, U.S. policy makers have tried to address the related goals of economic competitiveness and technology commercialization. This effort has taken the form of legislation that encourages federal laboratories to use its large investment in government agency research to help address the concerns of private industry.

Since its founding, NASA has played a leadership role in government-industry interaction. The Space Act of 1958 established a basis for transferring new technologies to the nation's industrial and academic institutions. The Act stipulates that NASA "provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."[1]

In response to this mandate, NASA developed a system of Technology Utilization Offices (TUO's), which collect and disseminate New Technology Reports (NTR's), descriptions of new technology and innovations generated by NASA contractors and field centers. The system has been in place since the early 1960's.

The introduction in 1987 of an automated Technology Utilization Network System (TUNS) improved the collection and dissemination of information on NASA-developed technology. The system gave the NASA Technology Utilization (TU) program a centralized means for acquiring and reporting new technology created at its various field centers. Prior to this, such reporting had been fragmented and varied greatly from center to center. TUNS also gave policy makers a tool to assess the impact of NASA's technology transfer programs.

Although TUNS represented an improvement over the previous system, its effectiveness in promoting technology transfer is limited by aging technology, and incompatible communication architectures. The size and complexity of the system hamper expeditious input of data into NTR's, and NTR data itself is often incomplete or of poor quality. Furthermore, cumbersome database search tools limit information retrieval. Consequently, users do not vigorously use many TUNS capabilities -- and some centers do not use the system at all.

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[1]National Aeronautics and Space Act of 1958 (42 U.S.C. 2473), Section 203(a)(3).

Problem Solution

The NASA Technology Transfer Network Communications and Information System (TCIS) is an open architecture, computer and network-based technology transfer structure that will revise, upgrade, and eventually replace TUNS. TCIS is designed to eliminate the deficiencies and technical problems embedded in TUNS, increase acquisition and dissemination of new technology, decrease the time between new technology acquisition and dissemination, and identify and track technology transfer benefits. Under the direction of the Office of Commercial Program's Technology Transfer Division, TCIS will provide the tools to manage new technology information and communicate this information to identified industry needs.

NASA's concept of technology transfer continues to evolve. In 1991, the agency made its network of technology transfer centers more responsive to industry by offering a broader complement of technologies and business expertise geared to selected regional firms. The next-generation communications and information system must likewise evolve into an effective resource to support NASA's leading role in customer-driven technology transfer. TCIS will directly address customer needs by: 1) building a large but easily accessible, high-quality database that technology transfer agents can readily draw upon in responding to industry demand; and 2) providing a communications network that enables these agents to participate with customers in identifying and solving problems.

TCIS offers a set of tailorable modules within an open architecture framework, thereby increasing its flexibility and usefulness as a technology transfer tool. By applying upgraded computer and communications technology, NASA will eliminate systemic bottlenecks that plague TUNS. It will accelerate the growth of and communication between technology transfer databases within and outside NASA, and promote the dissemination of technically useful information to the scientific and industrial communities.

TCIS users will consist of NASA technology transfer agents, submitters and acquirers of New Technology Reports (NTR's), contractors involved in the evaluation and publication of information on new technology, TU managers at NASA and firms contracting with NASA, and TCIS developers and operators. U.S. industrial R&D managers, scientists, and engineers will be the primary end customers for TCIS information products and services.

TCIS will achieve its goals by accomplishing the following:

- Transfer the TUNS central data repository to a more accessible and useful host computer or Data Center.

- Update technologies used in local systems, with an emphasis on deployment of open architecture tools and improved user interfaces.

- Establish standard database architectures to assist local and central interoperability among multiple computer platforms and environments, e.g. PC, Macintosh, and Unix.

- Extend capabilities to disseminate centrally located data to local sites in order to facilitate customized reports and efficient data searches using technologies such as CD-ROM.

- Enhance identification, collection, and availability of benefits data (i.e., information on technology that has been transferred to organizations outside NASA for successful application or use).

- Provide tools to aid information exchange with other government programs.

The TCIS open architecture design will be responsive to user needs and employ standard, modular components. The system will be tailorable to meet local requirements and to develop value-added, end-user products. Common, system-wide TCIS components will consist primarily of standards that define data structures and policies for data access, qualification, and dissemination, as well as software modules that support these standards. Mandatory components will be kept to a minimum in order to avoid unnecessary complexity, excessive data entry workload, and system bottlenecks.

A flexible development process that builds upon lessons learned with TUNS will ensure that TCIS provides useful components and tools to leverage the considerable talents and technical capabilities of the many individuals and organizations performing NASA technology transfer. TCIS system development will be based on the Rapid Development Method (RDM). RDM takes an iterative approach to software development in which product requirements are defined through a series of incremental deliveries that fully involve customers in development. Rapid system development, entailing fast delivery of software products, will boost the knowledge base and capabilities of system practitioners.

In brief, TCIS will take advantage of NASA's immense capabilities in research, development, and engineering to benefit the public, helping to further increase economic growth and the competitiveness of U.S. industry.

1.0 INTRODUCTION

1.1 Identification

This is the Concept Document of the Product Specification for the NASA Technology Transfer Network Communications and Information System (TCIS), developed at the direction of NASA's Office of Commercial Programs, Technology Transfer Division. TCIS will upgrade and replace the currently deployed Technology Utilization Network System (TUNS).

1.2 Scope of Document

TCIS builds upon the experience gained during TUNS' development and implementation. This Concept Document provides the outline and context for the TCIS information system's evolving functional requirements, and it is the parent document for development of detailed technical and management plans. TCIS Requirements Documents eventually will serve as the governing product specification. This document complies with the NASA Software Documentation Standard (NASA-STD-2100-91), and has been tailored to provide a broad understanding of TCIS capabilities and goals.

1.3 Purpose and Objectives

The purpose of this document is to provide an overview of TCIS. The document describes the TCIS mission and program scope, intended user community, software engineering approach, basic capabilities and characteristics, and potential operations. It establishes a foundation for TCIS management plans, engineering documents, and products. The Concept Document will express the program mission to TCIS users and managers and provide a basis for their review. The document will be altered in response to reviewer feedback and changes in program plans.

1.4 Status and Schedule

This is the draft baseline Concept Document prepared for the purpose of final review. This version reflects revisions made in response to directions that NASA provided in September 1992. The document is scheduled for baseline in the first quarter of fiscal 1993.

1.5 Document Organization

This document is comprised of eight sections including this introductory section. The other sections are:

- **2.0 Related Documentation** - This section identifies laws, regulations, fundamental NASA policies and standards, and other documents that provide background, historical perspective, and related policy and technical information.

- **3.0 Definition of the Program** - This section provides the rationale behind the original TUNS development, and the motivation, description, goals, approach, and program measurement practices for the TCIS program.

- **4.0 User Definition** - This section identifies broad categories of TCIS users, and describes their responsibilities.

- **5.0 Capabilities and Characteristics** - This section presents general TCIS capabilities and characteristics, including the software development process and a functional overview of TCIS products.

- **6.0 Operational Scenarios** - This section presents realistic scenarios of how industry representatives and NASA technology transfer agents might actually make use of TCIS.

- **7.0 Abbreviations and Acronyms** - This section lists definitions of abbreviations and acronyms used in this document.

- **8.0 Appendix: TUNS User Survey** - This appendix presents a summary of results from the TUNS User Survey which identifies deficiencies in the current information system and provides suggestions for system-wide improvements.

As part of the ongoing TCIS program, documents that describe TCIS requirements, capabilities, and architectures will be written in response to customer requirements and in accordance with NASA software engineering standards. These publications will include a software requirements specification, test and acceptance documents, and user manuals. Quality assurance measures will be developed and implemented in the course of TCIS development.

2.0 RELATED DOCUMENTATION

This section includes full citations for documents that are referenced in this publication, or standards, reports, policies and other source materials that are relevant to the TCIS concept.

2.1 Applicable Policies and Regulations

The following documents provided background and historical reference and defined fundamental NASA policies and standards:

1. National Aeronautics and Space Act of 1958 (42 U.S.C. 2473), Section 203(a)(3).

2. NASA Acquisition Regulation, Supplemental Directive (April 1, 1984), Subpart 18-27.372, Policy.

3. NASA Software Documentation Standard, NASA-STD-2100-91, July 29, 1991, Software Engineering Program, Office of Safety and Mission Quality, Washington, D.C.

4. NASA Management Plan for Government Open Systems Interconnection Profile (GOSIP) Implementation, February 1992, prepared by the NASA GOSIP Management Steering Group.

2.2 Informational Documents

Documents prepared to support TUNS development were examined during the preparation of this Concept. These include the following documents, listed in order of publication or delivery date:

1. NASA's New Technology Reporting System: A Review and Future Prospects, Denver Research Institute, University of Denver, May 1985, NASA Contract NASW-3466.

2. Required System Characteristics, System Architecture and Operations Concept, Computer Technology Associates, Inc., May 1986, NASA Contract NASW-3774.

3. Improving New Technology Reporting: Guidelines to Mobilize NASA Technical Monitors, Denver Research Institute, University of Denver, July 1986, NASA Contract NASW-3466.

4. TUNS Functional Requirements Document, Information Systems & Networks Corporation, March 1987, NASA Contract NASW-4164.

5. TUNS Phase II, Functional Requirements Document, Release 1, Information Systems & Networks Corporation, February 1989, NASA Contract NASW-4164.

Furthermore, Applied Expertise prepared the following document to aid TCIS concept development:

- TUNS User Survey, Applied Expertise, Inc., February 1992 (see Section 8.0 Appendix).

2.3 Other Documents

The following documents were examined to further investigate the context for technology transfer and the TCIS concept:

1. An Exploration of Benefits From NASA "Spinoff", Chapman Research Group, June 1989, NERAC Contract 88-01.

2. Mowery, David C., and Rosenberg, Nathan, Technology and the Pursuit of Economic Growth, 1989.

3. Schriesheim, Alan, "Toward a Golden Age in Technology Transfer," Issues in Science and Technology, Winter 1990-1991.

4. General Accounting Office, Diffusing Innovations: Implementing the Technology Transfer Act of 1986, May 1991.

5. Spinoff 1991, NASA Office of Commercial Programs.

6. Hlava, Marjorie, Consulting Report on the NASA Technology Utilization System, Access Innovations, 1992.

7. Goldin, Daniel S. (NASA Administrator), Address to NASA Employees, April 1, 1992.

8. Spuck, William H., "The Rapid Development Method," Jet Propulsion Laboratory, April 24, 1992, Draft.

9. National Academy of Sciences (NAS), The Government Role in Civilian Technology, National Academy Press, Washington, D.C., 1992.

3.0 DEFINITION OF THE PROGRAM

The NASA Technology Transfer Network Communications and Information System (TCIS) is a set of integrated computer and network-based tools and interfaces for technology transfer that will upgrade and replace NASA's currently deployed Technology Utilization Network System (TUNS). The system will provide its users with core data and communications on innovations relevant to technology transfer.

The currently deployed TUNS mechanism consists primarily of a collection of local computing resources, typically MS-DOS microcomputer networks that gather and process data. TUNS also includes a central repository containing new technology and benefits data transmitted from local TUNS sites. The central repository uses proprietary Adabas/Natural database technology running on an Amdahl mainframe.

3.1 Purpose and Scope

TCIS is designed to increase acquisition and dissemination of new NASA technology, decrease the time between acquisition and dissemination, and identify and track technology transfer benefits. TCIS will serve NASA's technology transfer community by providing the tools to manage, evaluate, and disseminate information on new technology. It also will assist in measuring the ancillary benefits of NASA research and development activities. Furthermore, TCIS provides a means of communicating industry needs for information on NASA innovations.

3.1.1 Background: Technology Transfer and U.S. Competitiveness

In recent decades, at least two major trends have alerted policy makers to possible weaknesses in the performance of U.S. industry. First, there has been a significant decline in the growth of labor productivity. Labor productivity grew annually at an average of 3.3 percent between 1948 and 1965; since 1970 the growth rate has averaged only 1.2 percent.[2] Second, U.S. industry faces much stiffer foreign competition in markets that had been its exclusive domain, including markets for high technology goods.

While the exact causes of these trends are debated, their effects are more certain. The drop in productivity growth has been largely responsible for a general decline in the growth of real wage earnings for U.S. workers. For the first time since World War II, younger Americans today face the prospect of earning less than their parents. In addition, heightened foreign competition in manufacturing has contributed to significant losses of market share, both at home and abroad, in many important industries -- including semiconductors and automobiles. In numerous other

[2] See National Academy of Sciences, The Government Role in Civilian Technology, National Academy Press, Washington, D.C., 1992.

cases, as with transistors and video cassette recorders, competitors like Japan have successfully captured commercial markets for technologies invented in the U.S.[3]

The relative success of principal U.S. competitors in manufacturing sectors has been attributed to a number of factors, including: 1) well-educated work forces; 2) aggressive government policies in promoting new manufacturing sectors; 3) emphasis on "continuous incremental improvement" of products and processes; and 4) ability to quickly transform basic scientific research into viable products. At the same time, U.S. industry has been criticized for falling short in these areas.

While U.S. laboratories are recognized for their strengths in basic research, Japan, other nations in East Asia, and Europe are credited with abilities in "pre-commercial R&D" -- research activities that serve as a foundation for commercial product development but are too expensive or generic for any one company to undertake on its own.[4] These abilities have helped give U.S. industrial competitors an edge in rapidly turning new technology into products.

Concerned about the nation's ability to disseminate and apply research innovations to its manufacturing enterprises, during the 1980's Congress passed a series of legislative initiatives on technology transfer from the federal labs. The legislation sought to enhance U.S. R&D capabilities by leveraging for private industry the vast talent of the federal research labs and their $20 billion in annual expenditures. Hoping to forge stronger ties between the labs and private corporations, Congress removed obstacles to organizational linkages and intellectual property rights protection. Congress also mandated technology transfer as a mission of the labs.[5]

The Stevenson-Wydler Technology Innovation Act of 1980 required federal labs to set up Offices of Research and Technology Applications (ORTA's) responsible for answering industry requests for information on technologies the labs created. Congress supplemented the Stevenson-Wydler Act with the Bayh-Dole Patent and Trademark Amendments Act, which allowed most non-weapons labs to patent their own inventions and license them to private firms for commercialization. Firms then could for a limited time become sole suppliers of new technologies. The intent of this provision was to provide companies with financial incentives for

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[3]Mowery, David C., and Rosenberg, Nathan, Technology and the Pursuit of Economic Growth, 1989, p. 219-220.

[4]See National Academy of Sciences, The Government Role in Civilian Technology, National Academy Press, Washington, D.C., 1992, p. 15-16.

[5]See General Accounting Office, Diffusing Innovations: Implementing the Technology Transfer Act of 1986, May 1991, pp. 76-77.

technology commercialization that might otherwise be absent if the products of federal research became automatically and freely available for public, as opposed to commercial, use.[6]

Both pieces of legislation supported the "technology-push," and the closely related "linear model," approach to technology transfer. According to this approach, when a research lab makes a discovery in the course of fulfilling its own mission, it "pushes" the new technology into the commercial marketplace. A recent National Academy of Sciences report on government support for civilian R&D describes the linear model's view of technology transfer:

> "[It] suggests that ideas originate in pure research and are transferred to applied research and, from there, on to advanced development and manufacturing."[7]

As technology transfer specialists at NASA and other agencies have discovered, however, the creation and adoption of commercial technology is an <u>iterative process</u> requiring two-way communication among research, development and manufacturing organizations. Effective technology transfer requires, therefore, not only "technology push" but also "market pull," in which the needs of private industry and manufacturing are actively considered in helping to determine what research problems are addressed in the government labs.

The Federal Technology Transfer Act of 1986 recognized this two-way dynamic by authorizing cooperative research and development agreements (CRADA's) between government and industry, with protection for intellectual property rights. These provisions were widened under the 1989 National Competitiveness Technology Transfer Act. The first major experiment in using CRADA's took place in 1988 with the Department of Energy's High Temperature Superconductivity Pilot Centers. In this program, the research goals of industry and government converged, and results were highly successful.[8]

In contrast to the more recent activities of other federal agencies, NASA since its inception has been actively involved in technology transfer. In fact, NASA's predecessor, the National Advisory Committee for Aeronautics (NACA), was largely responsible for developing and disseminating many key early aircraft innovations such as airfoils and an engine cowl.[9] The technology transfer legislation of the last decade is fully consonant with NASA's mandate to "provide for the widest practicable and appropriate dissemination of information concerning its

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[6]Schriesheim, Alan, "Toward a Golden Age in Technology Transfer," <u>Issues in Science and Technology</u>, Winter 1990-1991, p. 53.

[7]National Academy of Sciences, p. 13.

[8]Schriesheim, p. 53.

[9]National Academy of Sciences, p. 39.

activities and the results thereof."[10] The NASA system of New Technology Reports (NTR's), produced by its field centers and contractors, has been in place since the early 1960's. NTR's provide summary descriptions of NASA-developed technology to scientists and engineers throughout the aerospace and other industries. Furthermore, the NASA Centers for the Commercial Development of Space and NASA publications like Spinoff have long recognized the commercial benefits that can accrue from government-funded aerospace research.

The 1987 introduction of an automated system, TUNS, represented an improvement in the collection and dissemination of information on NASA-developed technology. TUNS was able to increase the volume of new technology reported and reduce the time between the development of new technology and its availability to technology transfer customers. The system gave the NASA Technology Utilization program an in-house means of promoting technology transfer and a centralized way of acquiring and reporting new technology created at various NASA field centers. Prior to TUNS, such reporting had been fragmented and varied greatly from center to center. TUNS also gives policy organizations tools to assess the extent and effect of technology transfer from NASA.

The NASA concept of technology transfer has continued to evolve. In 1991, NASA restructured its network of technology transfer centers to respond more effectively and flexibly to industry needs. Under the Regional Technology Transfer Centers (RTTC's), a broad complement of technologies and business expertise is offered which is geared to serving the requirements of selected types of regionally based firms. The centers are supported by the National Technology Transfer Center (NTTC), located in Wheeling, West Virginia. The next-generation communications and information systems must likewise evolve into a resource to support NASA's leading role in customer-driven technology transfer. TCIS can fulfill this role by: 1) building a large, high-quality database that technology transfer agents can draw upon in responding to industry demand; and 2) providing a communications network that enables these agents to share both information on customer problems and ideas on how to solve those problems.

3.1.2 Problem Statement

Technology transfer between the federal laboratories and industry is currently an unsystematic, serendipitous process: relatively few companies are aware of the types of research conducted at the labs, the potential commercial value of that research, or how they can gain access to research results. Technology information is passed from labs to industry through a variety of means, such as publications and conferences. However, these efforts are limited either in the number of industry representatives that can be reached or in the speed with which the information can be disseminated. An effective, automated information system can provide the opportunity for swift, broad access to valuable technology information.

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[10] National Aeronautics and Space Act of 1958 (42 U.S.C. 2473), Section 203(a)(3).

To address problems in technology dissemination, NASA developed TUNS, an automated technology transfer system. However, TUNS does not provide as rapidly as possible the quantity and quality of data that is required. As a result, less technology is adopted for commercial purposes, and thus NASA is not fulfilling its congressional mandate to transfer technology as effectively or as efficiently as it should.

A number of federal technology transfer studies have identified institutional barriers to transferring the results of government research to industry. For example, government lab research is generally not tailored to industry needs, and labs do not provide industry with the kind of market-oriented, state-of-the-art technology and information needed to stay ahead of competitors. In addition, some industries lack the capacity and expertise to take advantage of innovations generated by NASA and other government agencies.[11] These are not the kind of barriers that an information system itself can overcome, although the barriers themselves could adversely affect the success of the information system.

Despite these obstacles, NASA has an extensive pool of valuable technology, as well as scientific and engineering expertise, that industry can use to improve its products and manufacturing processes. For NASA field centers to leverage the national investment in their R&D, they must find ways to better respond to industry's R&D requirements. Through a reorganization of its technology transfer network, NASA has begun to focus on providing information and services that are driven by the needs of selected industries. By setting up regional and national technology transfer centers with links to NASA labs and other federal research facilities, NASA will enhance industry's ability to find, select, and adopt its technology.

A key part of NASA's overall technology transfer effort is the creation of an effective information and communications system to link R&D producers with technology transfer agents and their customers. While such a system cannot solve the entire technology transfer problem, it can provide the links to spur rapid dissemination of information about available NASA technology. By serving as a means of accessing a range of valuable information, the system can provide a flexible tool for technology transfer agents.

The current information system, TUNS, has made some technical progress, but its effectiveness in promoting technology transfer is limited by several factors. (Section 8, an appendix that summarizes the TUNS User Survey, provides a survey of problems with TUNS.) Outdated technology, proprietary data rights, incompatible communication architectures, and the size and complexity of the system hamper expeditious input of new technology reports (NTR's). NTR data, when it is entered, is often sketchy or of poor quality, and benefits information is not thoroughly disseminated or easily searched. Slow, cumbersome database search tools and multiple menu screens limit information retrieval. As a result, users do not vigorously take advantage of many capabilities that TUNS offers -- or they do not use the system at all.

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[11]National Academy of Sciences, pp. 50-55.

In addition, TUNS has been limited to a few users within NASA, and it therefore has suffered from relative obscurity. In 1986, a consultant's study reported that NASA scientists and administrators were generally unaware of the specifics of New Technology Reporting, although they highly endorsed it in principle.[12] In a recent evaluation of TUNS, NASA was urged to more proactively identify TUNS' ultimate customers and build database products that respond to their needs.[13] It is significant that other, new technology databases with broader access than TUNS have gained much higher recognition, even within the NASA community.

TCIS will significantly alleviate the technical problems embedded in TUNS by streamlining the current system and by offering a set of tailorable modules within an open architecture framework. By applying upgraded computer and communications technology, TCIS will eliminate systemic bottlenecks that plague TUNS and accelerate information dissemination and the growth of technology transfer databases. Once an effective, flexible new information system is in place, the technology transfer community will be able to promote its use throughout the NASA scientific community, as well as throughout industry.

3.2 Goals and Objectives

The primary goal of TCIS is to enhance NASA's ability to transfer its technology to public and private organizations in the United States, such as manufacturing companies, environmental firms, and medical researchers. The following key objectives support this overall goal:

- **Improve access to technology information.** The current system hampers access to technology data in a number of ways. It is only available to users working in the MS-DOS computing environment. In addition, the search tools are cumbersome to use, the number of screens make browsing tedious, and access to the NTR database is complicated. Removing these impediments will make the data more accessible to a greater number of users.

- **Increase and accelerate new technology reporting.** By providing accessible, easy-to-use communications and database tools, TCIS will enable NASA innovators to pass information to Technology Utilization Officers (TUO's) at NASA field centers rapidly and with little effort. TUO staff thus can spend less time on data input and more time in pinpointing the sources and possible users of new technology. A larger database of new technologies will become available to the technology transfer community soon after they become known to the TUO's.

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[12] Improving New Technology Reporting: Guidelines to Mobilize NASA Technical Monitors, Denver Research Institute, University of Denver, July 1986, NASA Contract NASW-3466, p. 2.

[13] Hlava, Marjorie, Consulting Report on the NASA Technology Utilization System, Access Innovations, 1992.

- **Enhance the quality and accuracy of technology transfer data.** Data quality and accuracy can be ensured by review of data records in the central database against established criteria. The TU community and other consumers of NASA technology transfer data will develop these criteria.

- **Increase and accelerate benefits reporting.** TCIS software to standardize benefits reporting will help the collection of NASA spinoff information from technology transfer agents. Currently, this information is not systematically collected, limiting the benefits database to a set of abstracts of published spinoffs.

- **Increase and expand the use of information tools in NASA.** Streamlining databases, reducing the amount and complexity of data entry, and increasing the quality and accessibility of data will encourage more members of the TU community to use computer and communications tools as an integral part of technology transfer. By making forms available at NASA research centers via electronic mail, innovators themselves will be able to tie directly into the technology reporting process.

- **Expand TCIS use to additional government R&D programs.** As NASA improves its ability to collect and disseminate technology transfer data using electronic means, and builds an open architecture system to facilitate this process, the TU community can expand its sources of new technology information to non-NASA labs. These labs, in turn, may gain access to the NASA new technology database using off-the-shelf hardware and software.

TCIS will help increase and accelerate new technology acquisition through changes to and simplification of existing TUNS applications and network connections, and through addition of appropriate new tools and methods. TCIS will achieve these goals by accomplishing the following objectives:

- **Transfer the TUNS central data repository** to a more accessible and useful host computer or data center. The repository will provide a site for consolidation, qualification, and dissemination of the store of new technology and benefits information.

- **Update the technologies of local systems**, with an emphasis on deployment of non-proprietary, open architecture tools and improved, less complicated user interfaces.

- **Establish database architectures** to assist system interoperability among multiple computer platforms and environments, e.g., PC, Macintosh, and Unix.

- **Extend capabilities to disseminate data to local sites** to foster customized reports and efficient data searches, e.g., CD-ROM.

- **Enhance identification and collection of benefits data** to further reporting of spinoff information.

- **Provide tools to help information exchange** with other government programs.

Open architecture tools, off-the-shelf products, and standard technologies for data interchange will reduce complexity and enable applications that respond flexibly to local needs. In short, instead of being technology-driven, TCIS will be user- and cost-driven. This approach will broaden the scope of TCIS applicability and permit access and contributions by a larger audience.

3.3 Program Measurement

TCIS must demonstrate that it provides an adequate return on NASA investment and that the costs incurred justify the benefits achieved. To accomplish this, NASA program managers must have tools and procedures to evaluate whether technology innovations are: 1) identified and recorded accurately; 2) screened, evaluated, and disseminated promptly; and 3) applied and used to enhance and enrich U.S. commercial activities and/or other government programs.

The management axiom guiding TCIS quality assurance and performance evaluation is, "if you can't measure it, you can't manage it."[14] The principal objective of a performance evaluation should be to identify and analyze major variances between actual results and performance criteria or pre-established expectations. The structure for assuring the quality and measuring the performance of TCIS will be segregated into internal and external evaluations. TCIS steering committees, comprising NASA employees within the TU network, will establish the methods, processes, and criteria for measuring quality and performance. Peer review will be used by the committees as a means of determining methods to measure and evaluate quality and performance. Periodic management reviews will be conducted by an external evaluation team consisting of TUO's and other appropriate representatives of NASA and the external customer community to validate the accuracy and quality of information recorded and processed through TCIS.

To be meaningful, data transmitted by individual components of TCIS must be consistent in format and allow compilation into consolidated reports. TCIS users will develop the objectives, criteria, and measurements for identifying, recording, screening, evaluating, disseminating, and reporting new technologies and benefits. Quantitative measurements of performance may include: 1) the number of new technology reports submitted; 2) the number of new technologies recorded in local and central repositories; 3) the time lapse between the recording of a new technology and its submission to the central repository; 4) the number of new technology report requests evaluated in terms of potential applications; and 5) the number of new technologies obtained and applied by industry, academia, and other government organizations. Although collecting (and disseminating) information on benefits can be difficult, it is essential that benefits

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[14]Statement of Goldin, Daniel S. (NASA Administrator), Address to NASA Employees, April 1, 1992.

be recorded in as tangible a way as possible, by using such parameters as monetary savings, avoidance of cost, management improvements, enhanced effectiveness, and increased efficiencies.

3.4 Program Description

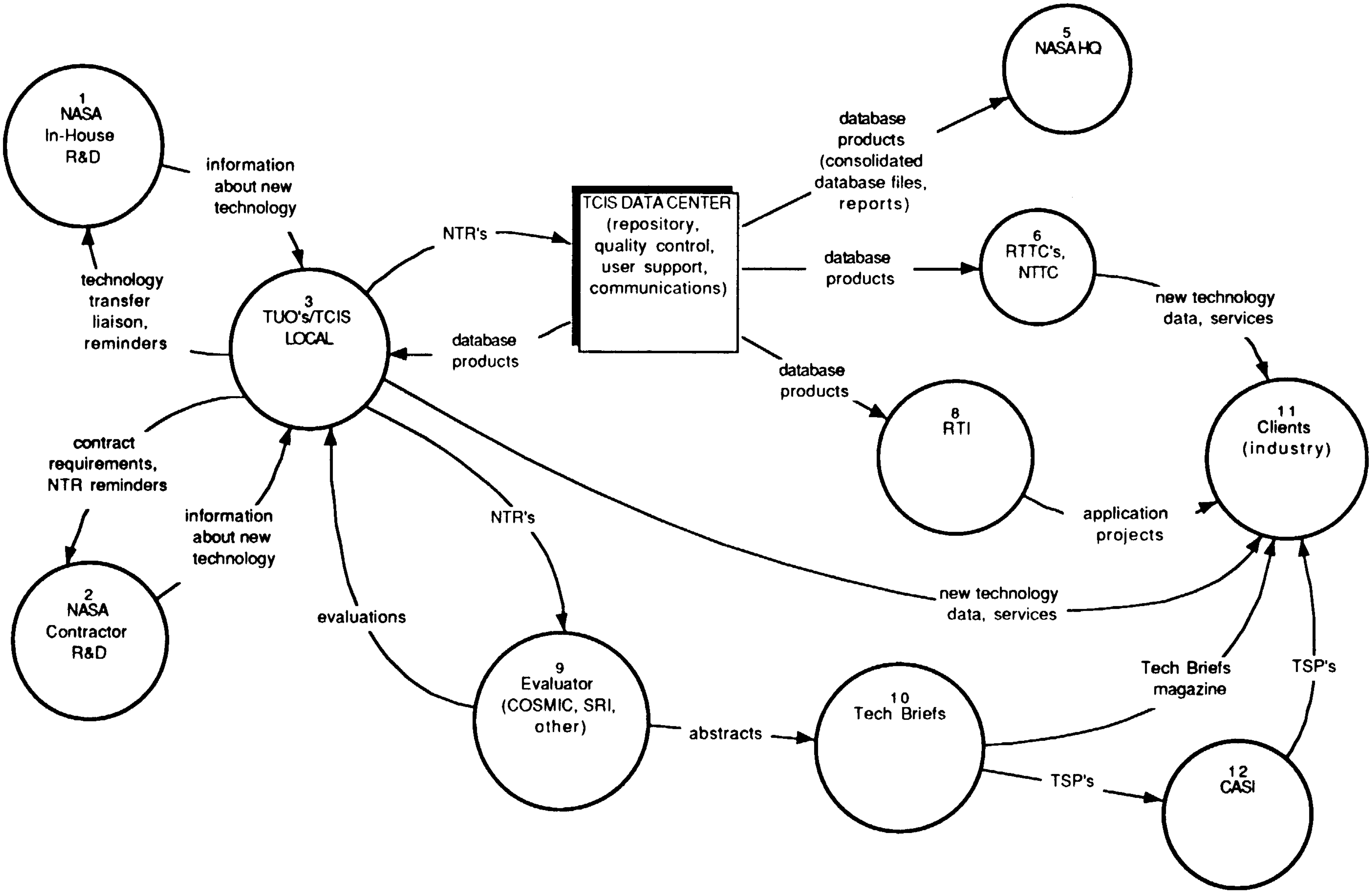
NASA supports technology transfer and utilization through a network of field centers that perform research, development and engineering; field center Technology Utilization Offices (TUO's); national and regional technology transfer centers; and related contractors and organizations. The communications and information system will focus on the core TU mission of acquiring and disseminating data on new technology reporting and technology transfer benefits. A Data Center will help assure the quality of repository data, assist users, develop TCIS applications, and facilitate communications. These major capabilities are described in the following sections.

3.4.1 New Technology Reporting (NTR) Data

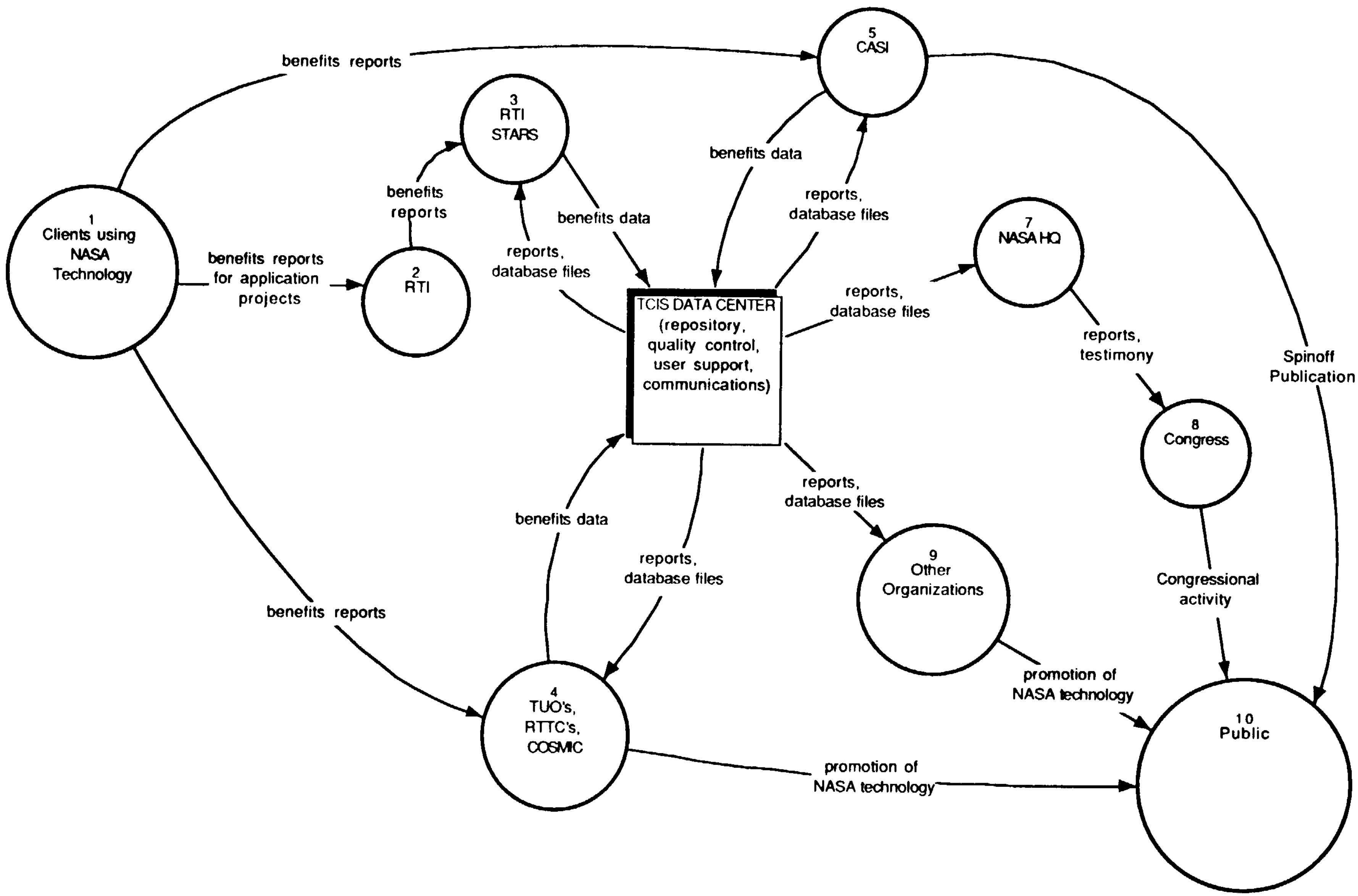
Figure 1 depicts the flow of new technology reporting (NTR) information that is envisioned for TCIS. TCIS receives NTR's from a variety of organizations and assists in transmitting NTR's to evaluators and interested representatives of industry. TUO's located at each field center collect NTR source data from NASA researchers and contractors. To increase the number of NTR submittals, TUO's track contracts and grants that require reporting of new technology, maintain liaison with contractor and field center lab personnel, monitor technical journals, attend conferences where technical papers are presented, and perform other activities to stimulate acquisition of new technology information. TUO's create NTR data records on local databases using TCIS.

At the appropriate time (e.g., following patent review), TUO's release these records to the TCIS Data Center, or central database. Then technology transfer centers, other TUO's, and the commercial Applications Team at Research Triangle Institute (RTI) can search and download information that responds to industry needs or stimulate coordination of experts for NASA-industry application engineering projects. The Data Center will also keep NASA Headquarters informed of the latest technology data acquisitions.

After making an initial assessment, the TUO's may send out NTR's for independent evaluation, typically to the Computer Software Management and Information Center (COSMIC) for software technology and to SRI International for other kinds of technology. NTR's accorded the highest evaluation -- based on the novelty, significance, and usefulness of an innovation -- are submitted for publication in NASA Tech Briefs. The Center for Aerospace and Scientific Information (CASI) maintains more detailed Technical Support Packages (TSP's) on published briefs. TSP's are sent to readers who request more data on the innovations summarized by Tech Briefs.



1 - New Technology Information Flow



2 - Benefits Information Flow

3.4.2 Benefits Data

Figure 2 depicts the flow of benefits information. While NTR reporting is required under contract and supported by various awards and other incentives, benefits reporting remains largely an informal process. By acting as a hub of information on the benefits of NASA technology transfer, TCIS will work to regularize reporting on technology transfer benefits. Users of NASA technology report benefits data to technology transfer centers, TUO's, COSMIC, CASI, and RTI, which will record and forward the information to the TCIS Data Center. In the case of RTI, benefits data would be funneled to TCIS through RTI's Spinoff Technology Application Retrieval System (STARS). The Data Center will consolidate, qualify, and disseminate benefits to TUO's, technology transfer centers, CASI, and NASA Headquarters. Other organizations would disseminate updated reports on benefits data to industry and the general public.

3.4.3 Data Center and Other Capabilities

The TCIS Data Center will provide a focus of support for the new technology and benefits information flows shown in Figures 1 and 2. The Center will consolidate, qualify, and disseminate new technology and benefits information; assist TCIS users; develop and support application modules; and facilitate communications. Initial Data Center activities will focus on building TCIS application modules and on transforming data from TUNS and other sources to the TCIS new technology and benefits information architectures. Following appropriate review and qualification, the Data Center will make this data available to NASA technology transfer community users (who in turn will use appropriate links to transfer new technology to customers in industry and academia). In addition to the construction and maintenance of tools and pathways for communicating technology transfer data, the Center will provide an electronic forum or bulletin board for communication of problem statements and other technology transfer information.

3.5 Policies

The use and application of TCIS is envisioned as an integral part of NASA's Technology Transfer program. Its mission is implicitly laid out in the Space Act of 1958, as amended. The statutory language for program authority in the area of technology transfer is stated as follows:

> The Administration in order to carry out other purposes of this Act, shall -- (3) provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.[15]

Procurement regulations reinforce NASA policy in regards to technology transfer, as follows:

[15]National Aeronautics and Space Act of 1958 (42 U.S.C. 2473), Section 203(a)(3).

> The objectives of NASA policy...are to obtain the prompt reporting of inventions, discoveries, improvements, and innovations made in the performance of any work thereunder (whether or not patentable) in order to protect the Government's interest therein and to provide the widest practicable and appropriate dissemination, early utilization, expeditious development and continued availability thereof for the benefit of the scientific, industrial, and commercial communities and the general public.[16]

Each TUO is also responsive to field center directives and policy. TU contractors are responsive to policies and practices delineated in their NASA contracts. Patent regulations and relevant contractual language govern the release and ownership of new contractor-developed technology.

As they evolve, policies to support NASA open systems and security requirements will further guide TCIS use and development.

[16]National Aeronautics and Space Act of 1958 (42 U.S.C. 2473), Section 305(b).

4.0 USER DEFINITION

TUNS is installed at the NASA Headquarters Technology Transfer Division, nine field centers, and seven contractor sites. The results of the TUNS User Survey revealed that system use varies from "none" to "extensive" at these sites, based primarily on the ability of TUNS to satisfy local requirements. (See the appendix in Section 8.) TCIS, in contrast, will provide more effective services to a larger community.

The NASA technology transfer community that TCIS will serve is pictured in Figure 3. TCIS users can be broadly classified into the following categories: industrial R&D participants, transfer agents, NTR submitters and acquirers, evaluation and publication contractors, and management and staff. This section outlines the relationship of each user category to TCIS.

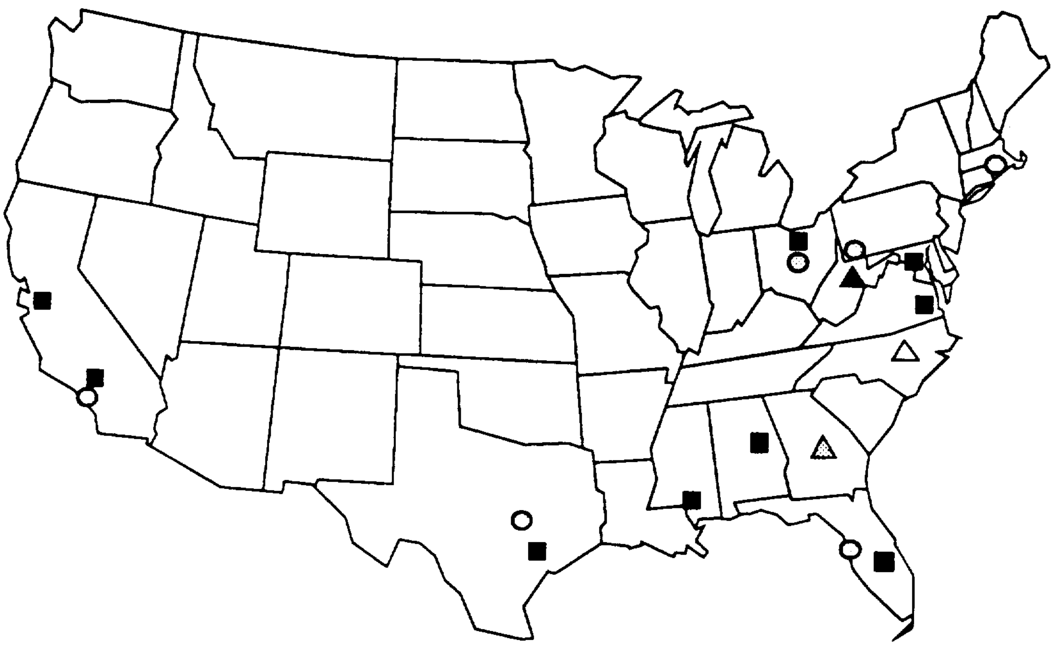
4.1 Industry R&D

The primary customers for TCIS data are U.S. industrial research and development managers, scientists, and engineers. They seek information that will help them to solve industrial problems, avoid technical roadblocks, and stimulate technical innovation. The industries served should extend well beyond aerospace to advanced manufacturing, microelectronics, medical devices, and environmental technology. The store of technology information managed by TCIS will be communicated to industry R&D customers through NASA's network of field center Technology Utilization Offices (TUO's), the Computer Software Management Information Center (COSMIC), Regional Technology Transfer Centers (RTTC's), the National Technology Transfer Center (NTTC), and other TU programs.

4.2 Transfer Agents

The primary agents for dissemination of NASA new technology to industry are TUO's, RTTC's and the NTTC. Three other facilities manage specialized technology transfer programs: COSMIC and the software engineering repository (AdaNET) offer NASA software programs and components to the public, and the technology Application Teams managed by Research Triangle Institute (RTI) assist in applying NASA technology to public sector and industry problems. TUO, RTTC and NTTC users will provide liaison between the TCIS store of technology information and customers in industry, academia, and government. The transfer agents also collect information on benefits customers derive from NASA technology.

As the system matures, selected portions of the TCIS database may be disseminated by users outside of the current network. These could include, for example, staff at Department of Energy labs or Strategic Defense Initiative Organization (SDIO) facilities. The NTTC will facilitate such intergovernmental technology transfer activity.



■ NASA Field Center TUOs

○ Regional Technology Transfer Centers

△ Research Triangle Institute

▲ National Technology Transfer Center

△ Computer Software Management and Information Center (COSMIC)

3 - NASA Technology Transfer Network

4.3 NTR Submitters and Acquirers

TUO's will use TCIS to collect, track, and manage NTR data acquired from contractor and in-house R&D programs. TUO's are the initial point of communication between R&D producers and TCIS. As the system matures, researchers, engineers and contractors will electronically transmit NTR's to TCIS, and new technology data will be submitted by other government R&D programs, where appropriate.

4.4 Evaluation and Publication Contractors

Several contractors assist TUO's with evaluation and review of new technology information. COSMIC evaluates software technology, and SRI International and field center teams evaluate other kinds of technologies. These users rate the novelty and utility of the technology and may also prepare abstracts of submissions. International Computers and Telecommunications, Inc. (ICT) also prepares and edits technology abstracts, assuring that publishable NTR's are complete and accurate. Highly rated NTR's are published in Tech Briefs, which is read by several hundred thousand engineers and managers in government and industry.[17]

4.5 Managerial and Staff Users

Management users at NASA Headquarters, TUO's, and contractor sites are interested in information that helps track progress toward TU goals. They require information on performance and output of staff (such as number of NTR's logged or published), contract administration, and budget and program status (such as the number of Application Projects that are nearing completion). Software developers and operators, either among TCIS contractor staff or at installed sites, require information on effective system usage, data integrity, configuration management, and quality improvement. TCIS applications will be aimed at satisfying these needs and other requirements as they develop.

Operational scenarios described in Section 6 provide illustrations of interactions between users and TCIS.

[17] Associated Business Publications (ABP) publishes Tech Briefs.

5.0 CAPABILITIES AND CHARACTERISTICS

Many TCIS capabilities are derived from the currently deployed, first-generation TUNS mechanism. While TUNS' implementation was highly problematic, the systems' requirements definition activities were extensive, based on preceding policy and program analysis work[18] and capturing customer feedback during the five-year TUNS development effort. For this reason, TUNS provides a significant base of technology and experience for derivation of TCIS capabilities.

The first major capability which is anticipated for implementation under TCIS is the core process of new technology data acquisition, management, and dissemination. The second capability planned for implementation is technology transfer benefits data management. Other capabilities will be implemented and/or refined in response to priorities set by customer demand, cost, and schedule. The development processes described in Section 5.1 provide the framework for delivering TCIS products in response to these capabilities and priorities. Sections 5.2 through 5.4 describe specific TCIS capabilities and characteristics.

5.1 Development Process

Because TCIS is derived from an operational system, many requirements and capabilities are well understood. The implementation of these capabilities as TCIS components will consist primarily of evaluation of precursor TUNS components, reverse engineering, and redevelopment using TCIS open architecture and functional standards. TCIS employs an innovative development process that delivers and installs capabilities in a step-by-step, iterative manner that benefits from continuous customer feedback. This approach saves time and money.

5.1.1 Rapid Development Method

TCIS will be developed in accordance with the Rapid Development Method (RDM), as articulated by the Jet Propulsion Laboratory (JPL).[19] JPL developed this process to address the need for accelerated product delivery within budget and schedule constraints. The four guiding principles of RDM are: 1) incremental deliveries; 2) requirements feedback; 3) progressive

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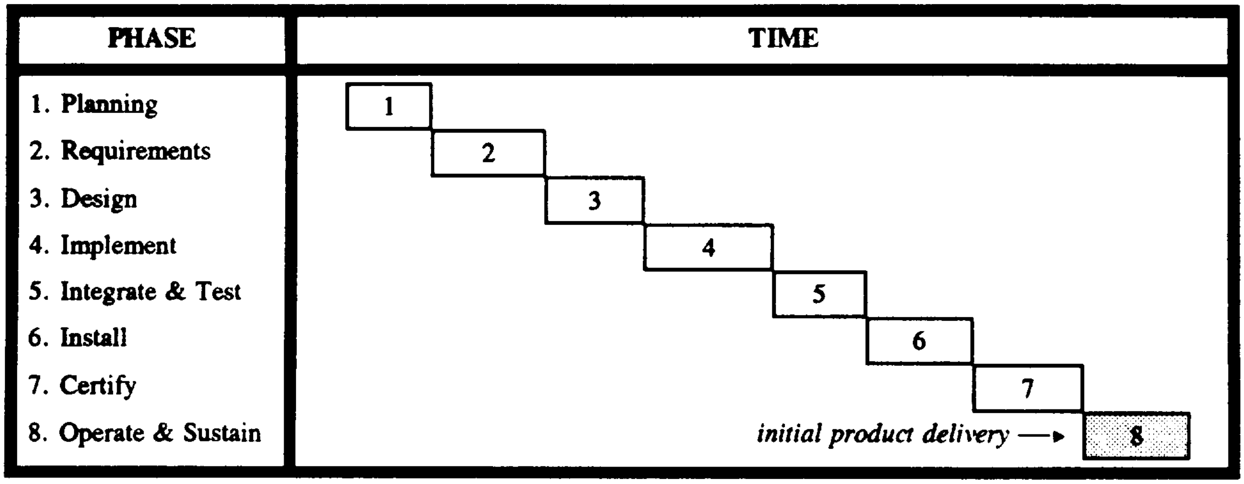
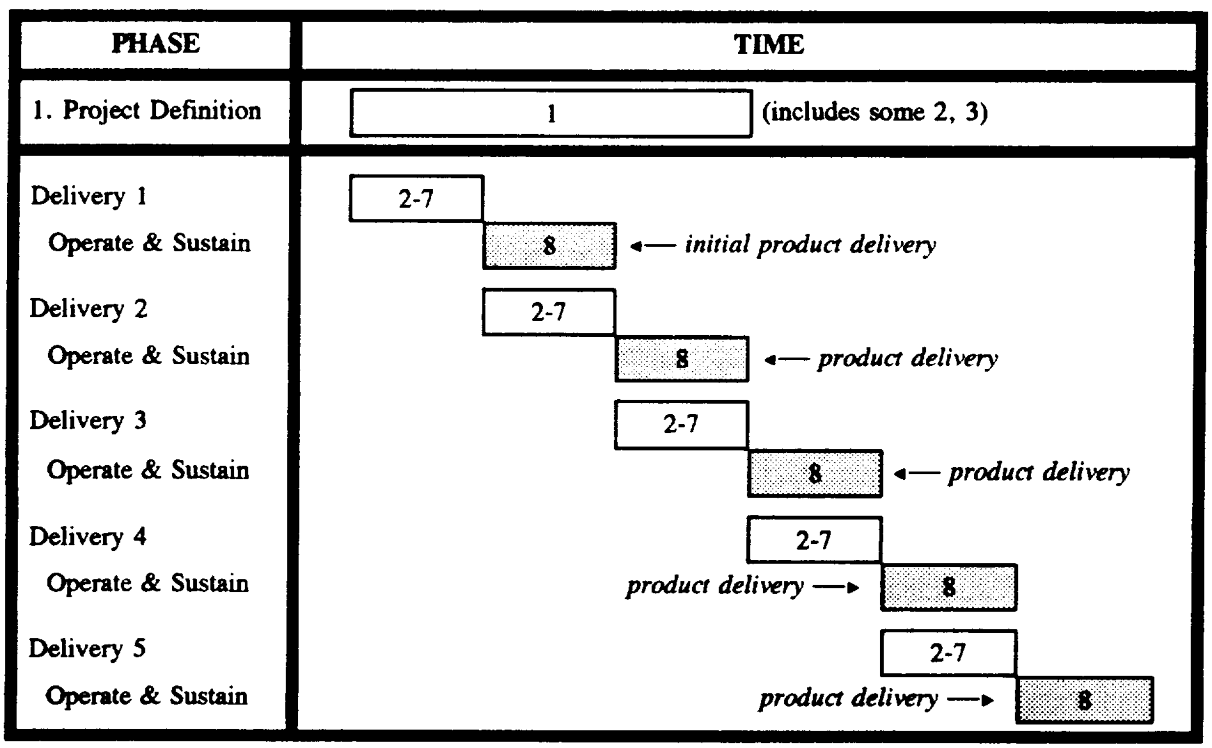
[18]See NASA's New Technology Reporting System: A Review and Future Prospects, Denver Research Institute, University of Denver, May 1985, NASA Contract NASW-3466, and Improving New Technology Reporting: Guidelines to Mobilize NASA Technical Monitors, Denver Research Institute, University of Denver, July 1986, NASA Contract NASW-3466.

[19]Spuck, William H., "The Rapid Development Method," Jet Propulsion Laboratory, April 24, 1992, Draft.

4 - Conventional Development Method Life Cycle (Waterfall)



5 - Rapid Development Methodology Life Cycle



formality; and 4) user interaction. It is a project management approach that seeks to circumvent problems commonly faced in conventional development methodology (CDM).

Under the CDM or "waterfall" approach, each phase in the system development life cycle occurs sequentially (see Figure 4). Planning is completely finished before requirements definition begins, requirements must be thoroughly defined and formally approved before design begins, etc. System deliveries do not occur until all preceding phases are completed, reviewed, and approved. Consequently, users typically receive actual products at least two years after project initiation. In addition, requirements and technologies frequently change after they have been baselined but before final software products are delivered (as was the case with TUNS, for example), thus complicating delivery of the end product.

In contrast, RDM calls for a series of incremental deliveries, at 6-9 month intervals. While delivery schedules and budget are major factors in driving the development process, under RDM users are also extensively involved. At the beginning of the project, users help determine initial system capabilities. With each successive delivery of the product, users gain experience with the system, and refine and expand their subsequent needs. Thus requirements, design, and functionality change over time, and these changes feed back into the development process and shape subsequent deliveries (see Figure 5). RDM reflects an iterative approach to software development in which requirements are refined until formulation of a specification that is correct, complete, and unambiguous. At the same time, RDM satisfies the desire of users and management to receive system deliveries earlier in the development cycle, and allows them to alter the system as needs evolve and budgets change. RDM activities are structured to ensure that quality software products will be produced during development.

Following completion of concept and management documents, overall requirements and schedules for TCIS will be determined through user requirements definition, technical analysis, and customer and management review. From this top-level planning, a subset of the TCIS requirements will be selected for the initial system delivery, based on priorities set by TU users and according to budget and schedule restraints determined by management. Once this delivery is operational, users and contractors will use the experience gained in developing, testing, and operating the system to refine requirements for the next delivery. With each delivery, the customer review process will improve the system's level of completeness and thoroughness.

5.1.2 RDM Software Engineering and Management

All the essential elements of software engineering and software management are inherent in the RDM approach. These elements will be applied throughout the RDM process to ensure the quality of TCIS software as it advances through its incremental development phases.

5.1.2.1 Software Engineering

As shown in Figure 5, all phases of the software development life cycle will be performed every successive RDM product delivery iteration. With each delivery, implementation procedures associated with the life cycle phases will become more formal, more comprehensive, and more thorough.

Modern software engineering techniques will be applied throughout the life cycle phases. The requirements analysis phase will incorporate: 1) reverse engineering; 2) information modeling; 3) structured analysis; and 4) requirements traceability techniques. These methods will be used to derive and track requirements for the TCIS software.

Reverse engineering will be applied to capture the current information content and functionality of TUNS. The knowledge gained from this activity will be used as the foundation for evaluating TUNS capabilities and providing lessons to improve the analysis and design of TCIS.

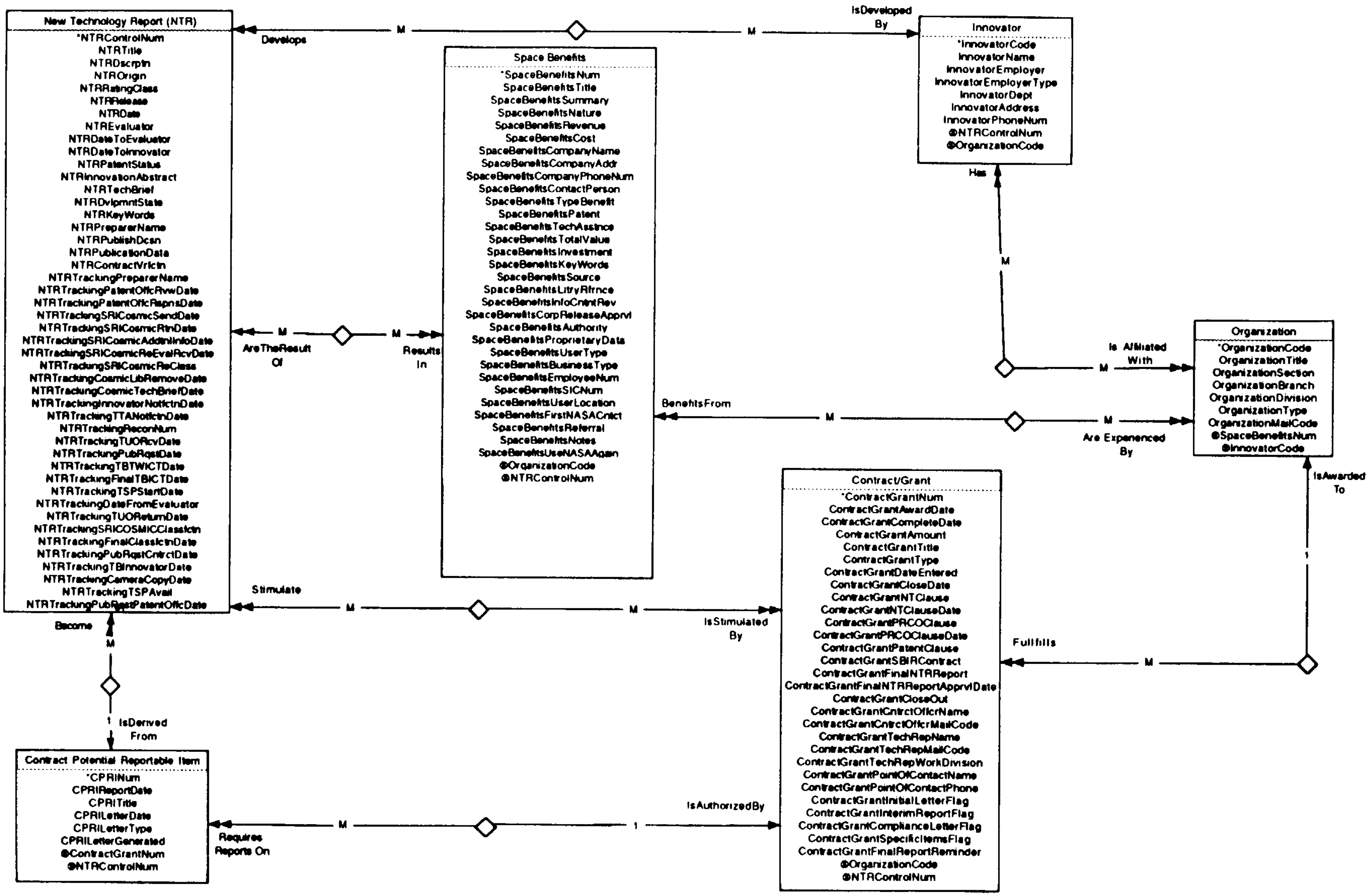
Information modeling techniques will be applied during requirements definition to identify the data requirements for TCIS. The purpose of information modeling is to establish a conceptual framework for TCIS in terms of the data components, thus identifying and formalizing all data that TCIS must process. One important goal is to make the data formats for TCIS more standard than they have been for TUNS. This is accomplished by specifying the full set of entities which TCIS must maintain and manipulate. The product of this activity is a conceptual database model, called the TCIS Information Model, consisting of an Entity-Relationship Diagram (ERD) and a Data Dictionary.

The ERD provides a graphical representation of the conceptual entities within TCIS. The model can be easily communicated among database analysts, designers and users. It identifies the entities in the TCIS problem space, specifies the characteristics of those entities, and establishes the relationships between them. For example, Figure 6 depicts a draft model of an ERD representing new technology data under TCIS.

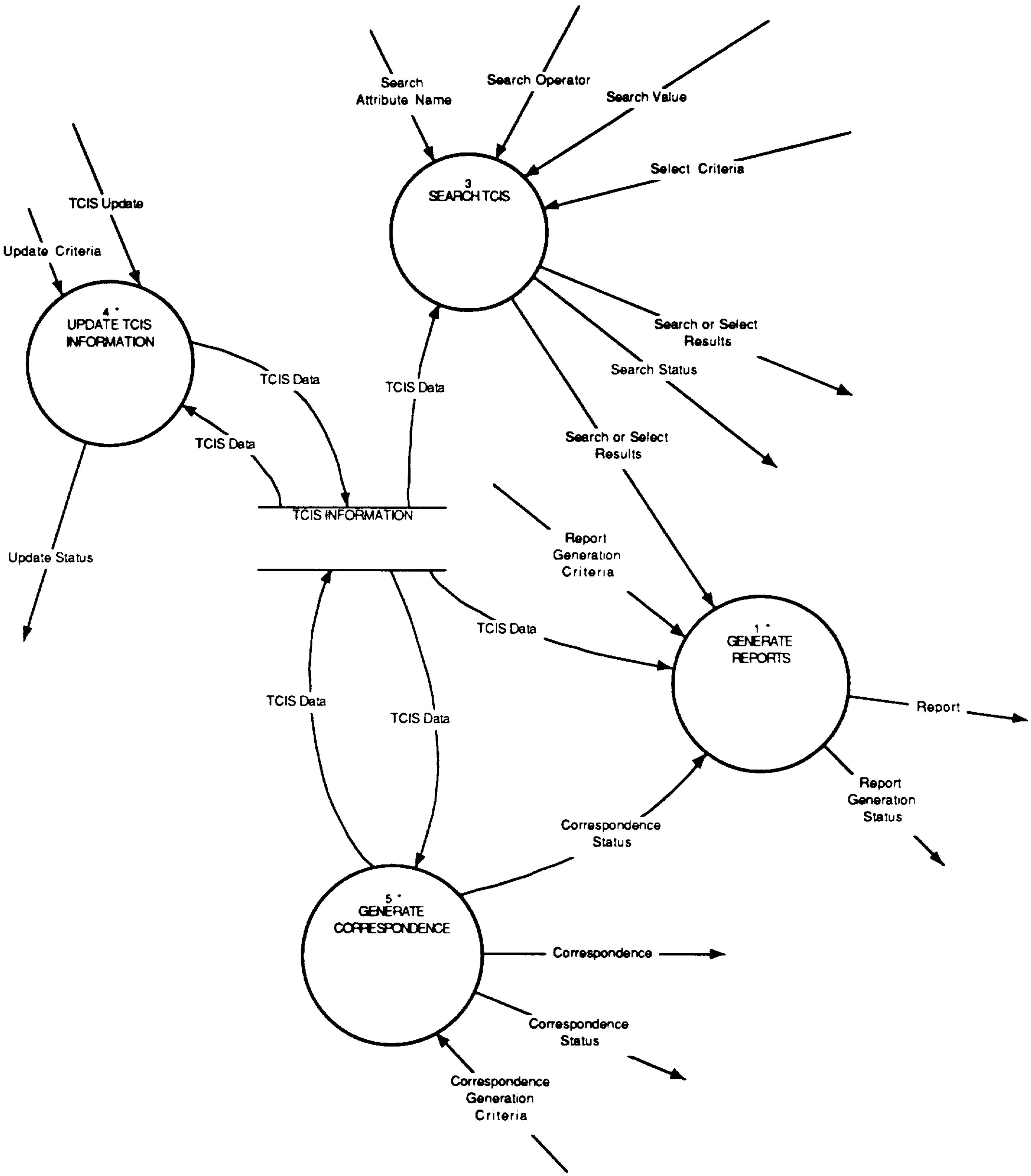
Participation of users will be the key determinant in the ability of the model to accurately represent the data. Discussions with users will be held to understand their unique business practices and information requirements, and should reveal many details critical to TCIS. The Data Dictionary component of the Information Model will be the repository of these essential details, and it will provide the mechanism for capturing and managing them.

The data processing requirements for TCIS will be derived using the conventional structured analysis methodology. Structured analysis is concerned with modeling the system in terms of the processes that operate on the data identified during information modeling. The application of this methodology will result in a set of processing requirements that are unambiguous and easy to communicate. The product of the structured analysis activity is a TCIS Process Model consisting of a hierarchical set of Data Flow Diagrams (DFD's) and Data Dictionary. The DFD's provide a graphical representation of TCIS functionality from the perspective of processes and information flow between processes. As with information modeling, the utility of the DFD's is augmented by a Data Dictionary containing descriptions of all objects in the DFD's. The processing defined using the structured analysis methodology will be documented in a TCIS

6 - Sample Entity Relationship Diagram



7 - Sample Data Flow Diagram



Software Requirements Specification (SRS). As an illustration, Figure 7 depicts a draft model of a DFD under TCIS.

Throughout the development effort, TCIS will provide the capability to track and trace requirements. This will be done through the use of a requirements traceability matrix (RTM) database management system (DBMS). The RTM can assure that elements of the design are accounted for by some requirement and that each requirement is satisfied by the design, thus precluding under-design or over-design. The RTM will point out discrepancies between design components and requirements; thus, it will provide a mechanism for checking claims made by the TUNS User Survey, TCIS Concept Document, and TCIS SRS.

The methodologies described above will be supported by advanced computer-aided software engineering (CASE) and DBMS tools. These tools will automate many software engineering tasks by capturing and managing the large volume of knowledge generated during the analysis and design phases.

Modern software engineering techniques integrated with the RDM approach will establish the hierarchy and structure of TCIS components and modules. This integrated approach will result in a stable, robust set of software requirements that will provide the foundation for a host of implementation options. This, in turn, will decrease development time and maintenance costs, and increase system reliability, software portability, and overall quality.

5.1.2.2 Software Management

Sound software management is vital to the success of TCIS. The overall management framework required to execute the TCIS software development effort will be established by NASA and contractor participants. This framework will reflect the estimated size and scope of the TCIS software and the RDM approach to TCIS development. Under RDM, it is important to define budgets and objectives in such a way that deliveries provide promised capabilities. The management effort therefore will focus on planning and controlling TCIS software development. A prime goal will be to ensure resources adequate for the successful, incremental delivery of TCIS capabilities.

The primary components of software management are scheduling, budgeting, monitoring, reporting, and resource management. Program management software will be used to assist in the administration of these components. Gantt charts, PERT charts, and resource allocation features of the software will identify tasks, depict dependencies between tasks, and help to manage resources to create realistic schedules.

5.1.2.3 Phased Implementation

TCIS implementation and support will take place in stages. A series of product deliveries, as determined by user input and time and budget constraints, will result in the final system. Each delivery cycle will last 6-9 months and offer a number of capabilities that support various technology utilization work practices. The TCIS work practices will include: NTR administration (NTR tracking and NTR reporting), contract/grant administration, benefits tracking and searching, technology utilization projects administration, system administration, and project management. In general terms, the work practices will be similar to those supported by TUNS. With each delivery, the number and quality of work practices, and TCIS support of them, will increase.

In accordance with the RDM approach, user requirements may be refined over time to reflect new work practices in support of TU. Delivery 1 will support NTR tracking and contract/grant administration (including correspondence). Delivery 2 may provide benefits tracking and network connections between central and local databases. Delivery 3 may provide technology utilization administration and an interface to the central database. Delivery 4 may provide project management. Delivery 5 may provide system administration. All deliveries subsequent to Delivery 1 will include enhancements, based on user needs, to the capabilities of previous deliveries.

Platform implementation and support will increase throughout the TCIS delivery cycle. Eventually, platform support will encompass Macintosh, PC, and Unix. As with TCIS capabilities, support for different platform environments may occur with subsequent deliveries.

The foundation for the various implementation environments is the TCIS Software Requirements Specification (SRS), which describes the software requirements for TCIS unrestricted by implementation choices. The SRS will initially be implemented in the Macintosh environment. Subsequent implementations may enable the PC/MS-DOS Windows and Unix environments.

5.2 Architecture

The Information Model, Process Model, and resulting Software Requirements Specification (SRS) will clearly describe TCIS data in terms of logical entities and their attributes, and the processes to be performed on that data. The requirements specified in the SRS can be implemented on different computer architectures. While specific implementation characteristics may differ from architecture to architecture, functional differences will be minimized. For example, different windows or icons may be used to invoke correspondence generation under the Macintosh and DOS Windows environments, but both architectures will perform the same correspondence generation functions.

The two primary end-user computing architectures for TCIS are the:

- Apple Macintosh using the System 7.x operating system, and the
- IBM-compatible PC using the Microsoft Disk Operating System (MS-DOS) with the MS-Windows 3.x or higher user interface.

TCIS may also be implemented to support end users with Unix computers operating with an appropriate graphical interface, depending on customer requirements, cost, and schedule constraints.

Most TCIS end user computers are connected to a local area network (LAN), which permits information and resource sharing and electronic messaging among multiple users. The networks in use in the TU community include AppleTalk, Novell Netware, MS LanManager, and Banyan Vines. TCIS will be engineered to operate in LAN environments. The wide area network (WAN) anticipated by the TCIS local and central database concept will be implemented using non-proprietary methods in order to promote broad data access capabilities, such as remote access from a laptop computer and high-speed connection through NASA's broadband network(s).

5.3 System Capabilities

The functional capabilities of TCIS represent a system-wide solution for user needs. System capabilities are derived from operational requirements that identify the varied work practices and needs of users within the TU network that TCIS will support. In addition, the functionality of TUNS is used as a resource to derive TCIS system capabilities.

TCIS will provide four basic capabilities in support of TU work practices. The capabilities are:

- Search, select, sort
- Information maintenance
- Report generation and correspondence
- Communications.

The search, select, and sort capability finds information in accordance with user criteria and performs multi-level sorts on it. Searched or sorted information can be displayed on screen or in printed reports. The information maintenance capability enables adding, deleting, or updating of TCIS data. The report generation capability creates reports according to user criteria. TCIS' correspondence feature generates and tracks the status of letters in support of new technology reporting for NASA contracts or grants and in-house research & development. The communications capability transfers new technology, TU, and benefits data between the central database and local databases of TCIS. Support for most of these capabilities will begin with Delivery 1, and enhancements to them will occur through subsequent deliveries.

Analysis of requirements for these capabilities will yield a system architecture, performance requirements, and specific user functionality. The analysis activity will be supported by user surveys and will begin by examining work practices, information requirements, needs of personnel, and technologies, all of which will be integrated to meet the goals established for TCIS.

5.4 Overview of System Activities

TCIS will provide new technology reporting as well as tracking and management of benefits data. Subsidiary activities may include modules for project management and planning and transmission of NTR evaluations. TCIS also will provide electronic communications among TU community members and linkage to the central data repository. Other activities will be provided in response to user needs and technical opportunities. The basic activities, which are examples of TU work practices, are described in the sections that follow.

5.4.1 New Technology Reporting

TCIS will provide tools to acquire new technology information from NASA labs and contractors, deliver that information to a central data repository, and disseminate central repository data to technology transfer centers and their customers. The central repository will contain a DBMS with a standard access method such as Structured Query Language (SQL). The central repository will provide a useful online search mechanism. The NTR database structure, or Data Dictionary, will be relevant and functional; that is, the Data Dictionary will contain the entities and attributes considered most useful by technology transfer agents and their customers. NTR data will be submitted in hardcopy or electronic form to TUO's.

In response to user requirements and technical opportunities, the system will provide additional methods for categorization, searching, and delivery of repository data. Repository data can be packaged as printed monthly reports or indices, delivered on CD-ROM with an appropriate search mechanism, or provided as SQL or DBF updates to local database hosts (e.g., for placement on a LAN file server). The open architecture database will permit input and searching of repository data from a variety of computer platforms and applications. TCIS will provide tools for uploading and, as needed, downloading new technology data for platforms and applications.

5.4.2 Benefits Data

TCIS will provide core tools and mechanisms to acquire, disseminate, and manage benefits information from TUO's, contractors, and technology transfer centers and customers. These tools will be developed in cooperation with the Spinoff Technology Application Retrieval System (STARS), a public-use benefits system developed by NASA and Research Triangle Institute. The central data repository will provide a location for consolidation of the space benefits information. This will permit analysis of NASA-wide space benefits data. TCIS tools will be designed so that they are also useful for management of local, non-centralized data. This will allow RTTC's to work with the proprietary benefit information of clients which should not be distributed to broader audiences. As with NTR's, benefits information will be structured with the goal of producing relevant data in an efficient manner, and will permit input and searching of repository data from a variety of computer platforms. TCIS also will deliver benefits data in multiple formats (e.g., CD-ROM).

5.4.3 Other Capabilities

Through its Data Center and other utilities, TCIS will provide capabilities in addition to reporting of new technology and benefits data. Applications may include modules that manage NASA-industry application projects, communicate results of NTR evaluations, provide an index of project plans such as NASA Research and Technology Objectives and Plans (RTOP's), track technology transfer awards, and provide management reports to NASA Headquarters. Additional tools and applications will be developed by knowledgeable users and computer experts throughout the technology transfer community. TCIS thus will promote sharing of locally developed tools or applications. A TCIS bulletin board and/or newsletter will provide an additional communication mechanism.

5.5 Flexibility and Expansion

Because TCIS will be built with open architecture modules, tools, and techniques, it will provide considerably more flexibility than TUNS. TCIS will be able to be modified and extended to meet many local requirements. Using appropriate tools or applications, information from TCIS databases will be combined or exchanged with other databases or applications, such as an RTTC customer list or a spreadsheet application.

Common, system-wide TCIS components will consist primarily of standards that define data structures (e.g., the new Data Dictionary). TCIS components also will include policies for data access, qualification and dissemination, and software modules that support the standards. To reduce TCIS complexity, data entry workload, and system bottlenecks, mandatory, system-wide components will be kept to a minimum.

6.0 OPERATIONAL SCENARIOS

This section contains illustrative examples of potential uses of TCIS by governmental and extra-governmental personnel and organizations.

6.1 Industry Application

The chief engineer of a company that sells equipment for use in casting steel identifies a problem his customers are experiencing: rollers are eroding and cracking due to thermal fatigue, and metal molds are corroding from contact with chemical fluxes. The engineer asks staff at a NASA research center to help him identify and develop materials technology that will extend the life of the equipment.

The TUO at the center works with NASA engineers to gain an understanding of the problem, and then begins to search for technology and experts that offer potential solutions. He searches a NASA-wide NTR database from his own computer to find technologies for resisting thermal stress and chemical corrosion and to point him to NASA materials engineers who have expertise in the area. The TUO transmits to the TU community or affiliated researchers a request for information using electronic mail or an online bulletin board system. As a result of these efforts, he discovers several potentially relevant technologies, and with the company engineer who requested help, selects three to apply to the problem: a high-temperature material used on a research plane, a spraying technique for applying the material to the rollers in a thin layer, and mold prototypes of metal composites that reduce corrosion. He also coordinates meetings with NASA experts who developed these technologies.

The company develops new products based on these technologies. The company increases its sales to the steel-making industry, which is able to use the rollers for a longer period before replacements. By following up with the company a year after the product has been introduced, TUO staff is able to determine the qualitative and quantitative benefits the company and its industry realized from the application of NASA technology. A staff member records this information in the benefits database on the local network and then uploads it to the central database for NASA-wide use. Technology transfer centers use this database in evaluating the potential of NASA technology transfer, and NASA management refers to this data in analyzing program effectiveness.

6.2 Management, Evaluation, and Publication of New Technology Reports

A TUO at a NASA field center learns of a new robotics technology developed for one of the center's programs. Data on the technology may have come from a patent disclosure form, contractor and in-house technical reports, or other new technology information. TUO staff complete an NTR form that resides on the local TCIS database. The NTR summarizes the innovation, its significance and technology status, and lists the names of the innovators. The staff also enters information through TCIS to enable them to track key dates, such as date received, date sent for evaluation, date of review. At the appropriate time, TUO's upload selected NTR's from their local database to the central repository. This action enables technology transfer centers and other TUO's to examine recent NASA advances.

The TUO sends available reports on the technology to experts who assess innovations for novelty, utility, and significance. Upon completion of its evaluation, the experts enter this information into the central evaluation database. TUO's then download the evaluations and draft synopses of top-ranked innovations, which are sent to the publishers of Tech Briefs. Several hundred thousand scientists and engineers read Tech Briefs, and hundreds order Technical Support Packages (TSP's) from the Center for Aerospace and Scientific Information (CASI). The TSP's summarize the synopsized innovations.

6.3 Software Technology Transfer

A TUO identifies useful or innovative software technology developed under contract to NASA or by in-house developers. Through queries to the innovator, the TUO determines that both a complete software package -- that is, a "shrink-wrapped" product that is ready for installation -- and software components such as design documents and requirements specifications (i.e., parts of a system used as building blocks in another product) have been delivered to NASA. He enters this information into the TCIS database. Via electronic mail, he alerts COSMIC and the NASA software component repository (AdaNET) to the new software. The TUO also arranges for contacts with the innovator or the NASA technical monitors so that NASA software repositories can obtain the software packages and components. The TUO also may wish to send a copy of the NTR record to COSMIC, and COSMIC can load the abstract and other relevant information into a database it developed to track its products.

COSMIC evaluates the software technology for its utility, significance, and innovativeness. Its staff tests and catalogs complete software packages, offering them at cost to government and industry users. Software components are sent to the AdaNET repository, where they are classified, cataloged, and loaded into the repository for dissemination to government and industry customers. These customers reuse the NASA components in their own software development efforts, reducing the cost of development and improving the maintainability of these new systems.

7.0 ABBREVIATIONS AND ACRONYMS

CASE	Computer-aided software engineering
CASI	Center for Aerospace and Scientific Information
CDM	Conventional Development Methodology
CD-ROM	Compact disk read only memory (optical storage)
COSMIC	Computer Software Management and Information Center
CRADA	Cooperative research and development agreement
DBF	Database Format (a structure compatible with the dBase/xbase industry standard)
DBMS	Database management system
DFD	Data Flow Diagram
ERD	Entity-relationship diagram
GOSIP	Government Open Systems Interconnection Profile
JPL	Jet Propulsion Laboratory
LAN	Local area network
MS-DOS	Microsoft Disk Operating System
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration
NTR	New Technology Report
NTTC	National Technology Transfer Center
OCR	Optical character recognition
ORTA	Offices of Research and Technology Applications
PC	Personal computer (typically, one which uses MS-DOS)
PSCN	Program Support Communications Network
R&D	Research and development
RDM	Rapid Development Method
RTI	Research Triangle Institute
RTM	Requirements traceability matrix
RTOP	Research and Technology Objectives and Plans
RTTC	Regional Technology Transfer Center
SDIO	Strategic Defense Initiative Organization
SQL	Structured Query Language
SRS	Software Requirements Specification
STARS	Spinoff Technology Application Retrieval System
STD	Standard
TCIS	NASA Technology Transfer Network Communications and Information System (pronounced tee-SIS, to rhyme with *thesis*)
TCP/IP	Transmission control protocol/internet protocol
TSP	Technical Support Package (a Tech Briefs product distributed by CASI)
TU	NASA Technology Utilization Division, or Technology Utilization program
TUNS	Technology Utilization Network System
TUO	Technology Utilization Office or Technology Utilization Officer
WAN	Wide area network

8.0 APPENDIX: TUNS USER SURVEY (SUMMARY)

Applied Expertise surveyed users of NASA's current information system, the Technology Utilization Network System (TUNS), and surveyed prospective new users to gather background information for developing a system to upgrade and replace TUNS.

Survey participants broadly agreed that automated mechanisms for acquiring, managing, and disseminating new technology and spinoff benefits information can and should play an important role in meeting NASA technology utilization goals. However, TUNS does not meet this need for most users. For example, the survey found that:

- The current TUNS configuration fails to eliminate delays and bottlenecks that impede the reporting and dissemination of New Technology Reports (NTR's).
- NASA benefits information is not systematically tracked and disseminated.
- Data entered into TUNS is often sketchy or of poor quality.
- NTR data is not useful to technology transfer centers for sifting through data to find potential solutions.
- TUNS is a cumbersome system for searching both locally and on the central database.
- Use of TUNS is limited to a few NASA sites, which pass on a limited number of NTR's and benefit reports to the central database.

The survey describes a number of systemic improvements that will make it easier to use the technology transfer mechanism, and thus expedite the collection and dissemination of technology information. The survey identified 26 suggestions for enhancing the technology transfer system and related processes. These included the following:

- Implement an open architecture, modular system that permits all users to gain access to data regardless of their local environment and allows them to port data back and forth across other non-system databases and applications.
- Streamline and modularize the current system to reduce the number of menus and data entry screens, and offer users only the modules they require.
- Make electronic forms available for researchers themselves to submit new technology information to Technology Utilization (TU) offices or other field center networks via electronic mail. This could eliminate effort expended in rekeying data and give the

researcher who is most familiar with the new technology the opportunity to create an accurate abstract for dissemination.

- Reexamine benefits database categories to include non-quantifiable categories and, potentially, to eliminate unnecessary data elements.

- Streamline the process for uploading benefits data to make it easy to collect and send.

- Explore ways in which some information about technology that is proprietary or awaiting release may be made available on a restricted basis while still protecting confidential portions of the information.

- Simplify central dial-up of the NTR database. In addition, the central NTR repository should be used to compile products such as CD-ROM or database update files that may be mailed monthly to technology transfer agents for convenient searching on their local machines.

Unless the system is designed for convenient searching of information, it will not be used and therefore will fail in its attempts to aid technology transfer. The survey found that technology transfer centers will eagerly use this system if it does the following: 1) provides new technology information from all field centers; 2) requires only a few steps to gain access to the information; and 3) provides this information rapidly, i.e., faster than it can be published or made available through other sources.

One Technology Utilization Officer (TUO) noted that the chief value of TUNS lies in making available to the Regional Technology Transfer Centers, other technology transfer agents, and the public the full range of NTRs -- not merely those that are highly rated and therefore eligible for publication. Otherwise, he said, the effort invested in building the TUNS database is wasted. Conversely, all TUO's must contribute to the central database if it is to be of value to the RTTC's.

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